10.1 The periodic table and periodic trends

Name: _____ Class: _____ Date: _____ **Total: 34 marks**

KEY WORDS period • group • ionization energy • atomic radius • halogen • oxidation state

Objective

Build the skills to answer exam questions on **the periodic table** : periods, groups and blocks, periodic trends, groups 1 and 17, oxides and oxidation states.

You must be able to:

- deduce the period, group and block of an element from its electron configuration
- explain trends in atomic radius, ionic radius, ionization energy, electron affinity and electronegativity
- describe the reactions of group 1 metals with water and of halogens with halide ions
- write equations for metal and non-metal oxides with water, and explain acid rain and ocean acidification
- explain the dips in first ionization energy across a period, and the properties of transition elements

1 Key knowledge and worked examples

■ Organizing the elements

The **period** number is the number of occupied energy levels; the **group** shows the outer electrons. The **block** (s, p, d, f) is the sublevel being filled: $[Ne]3s^2 3p^4$ is period 3, group 16, p-block (sulfur).

trend	across a period (→)	down a group (↓)
atomic radius	decreases: more protons, same shielding, electrons pulled closer	increases: more occupied levels
first ionization energy	generally increases	decreases: outer electron further away and more shielded
electronegativity	increases	decreases
metallic character	decreases	increases

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Positive ions are **smaller** than their atoms; negative ions are **larger**.

group	behaviour
1 (alkali metals)	$2M + 2H_2O \rightarrow 2MOH + H_2$; more reactive down the group (outer electron lost more easily)
17 (halogens)	a more reactive halogen displaces a less reactive one: $Cl_2 + 2Br^- \rightarrow 2Cl^- + Br_2$; less reactive down the group

Oxides: metal oxides are **basic** ($Na_2O + H_2O \rightarrow 2NaOH$); non-metal oxides are **acidic** ($SO_3 + H_2O \rightarrow H_2SO_4$); Al_2O_3 is amphoteric. SO_2 and NO_x cause **acid rain**; dissolved CO_2 causes **ocean acidification**. In a compound, an **oxidation state** is the charge an atom would have if all bonds were ionic.

HL: first IE dips at B (the 2p electron is higher in energy than 2s) and at O (two electrons share a 2p orbital and repel). Transition elements show variable oxidation states, coloured compounds, complex ions and catalytic activity.

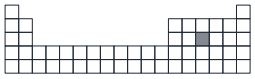
Worked example 1: radius. Na^+ (102 pm) is much smaller than Na (186 pm): it has **lost its outer level**.

Worked example 2: oxidation state. In SO_4^{2-}: $x + 4(-2) = -2$, so S is $+6$.

Answer shapes: nuclear charge, distance and shielding, then the effect on attraction.

2 Practice

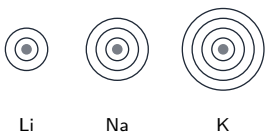
2.1 An element has the configuration $[Ne]3s^23p^3$. State its period, group and block. [2]



2.2 Explain why atomic radius decreases from sodium to chlorine. [3]

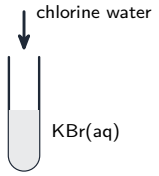


2.3 Explain why the first ionization energy decreases down group 1. [3]

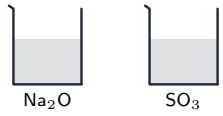


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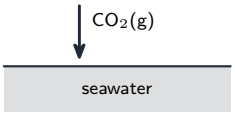
2.4 Chlorine water is added to potassium bromide solution. State what you would observe, write the ionic equation and explain the reaction. [3]



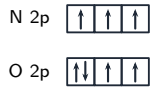
2.5 Write equations for the reactions of sodium oxide and of sulfur trioxide with water, and state whether each solution is acidic or alkaline. [3]



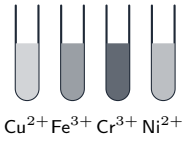
2.6 Carbon dioxide dissolves in the oceans. Write two equations to show how this makes seawater more acidic. [2]



2.7 The first ionization energy of oxygen is lower than that of nitrogen. Explain why. [2]



2.8 State two properties of transition elements, other than metallic properties. [2]



3 Exam-style questions

3.1 Potassium reacts vigorously with water, with a lilac flame.

(a) Write an equation, with state symbols, for the reaction. [2]

(b) Explain why potassium reacts more vigorously than sodium. [3]

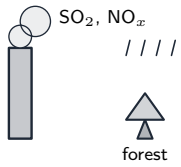
(c) State and explain the pH of the solution formed. [2]

(d) Describe and explain the trend in electronegativity across period 3. [2]

3.2 Burning fossil fuels releases oxides of sulfur and nitrogen.

(a) Deduce the oxidation state of sulfur in SO_2 and of nitrogen in NO_2. [2]

(b) Describe how acid rain forms from sulfur dioxide, and give one effect of acid rain. [3]



Solutions

Marking: **M1** a correct method, **A1** the correct answer, **B1** an independent mark.

Each answer shows the steps, then the **result**.

2.1

period 3, group 15; p-block

2.2

nuclear charge increases; electrons go into the same energy level, so shielding is similar; outer electrons are pulled closer

2.3

outer electron further from the nucleus; more shielding; weaker attraction, so less energy is needed

2.4

the solution turns yellow-orange; $Cl_2 + 2Br^- \rightarrow 2Cl^- + Br_2$; chlorine is a stronger oxidizing agent, so it displaces bromine

2.5

$Na_2O + H_2O \rightarrow 2NaOH$; $SO_3 + H_2O \rightarrow H_2SO_4$; NaOH alkaline, H_2SO_4 acidic

2.6

$CO_2 + H_2O \rightleftharpoons H_2CO_3$; $H_2CO_3 \rightleftharpoons H^+ + HCO_3^-$

2.7

in oxygen two electrons share one 2p orbital; the repulsion between them makes one easier to remove

2.8

any two: variable oxidation states; coloured compounds; form complex ions; act as catalysts; magnetic properties

3.1

(a) $2K(s) + 2H_2O(l) \rightarrow 2KOH(aq) + H_2(g)$

(b) outer electron of K further from the nucleus; more shielded; so it is lost more easily

(c) about 13–14 / strongly alkaline; hydroxide ions, OH^-, are formed

(d) electronegativity increases; nuclear charge increases with similar shielding, so bonding electrons are attracted more strongly

3.2

(a) S: +4; N: +4

(b) SO_2 reacts with water (and oxygen) in the air; forming H_2SO_3 / H_2SO_4; damages trees / limestone buildings / acidifies lakes

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